

Physicists discover the secret to perfect cacio e pepe pasta

The classic Italian cacio e pepe pasta is notoriously tricky to get right, but physicists have come up with a trick to achieve a perfectly smooth cheese sauce

By [Alex Wilkins](#) on January 10, 2025



Spaghetti cacio e pepe is made with black pepper and pecorino cheese. [myViewPoint/Alamy](#)

Physicists have discovered the key to a consistently delicious cacio e pepe pasta, a traditional Italian dish made with black pepper and pecorino cheese.

Cooking cacio e pepe involves melting the cheese with some of the water the pasta is cooked in to create a smooth sauce, but achieving this is notoriously tricky. If the mixture becomes too hot or has the incorrect balance of cheese and starch from the pasta water, then the sauce will become unpleasantly lumpy rather than smooth.

[Ivan Di Terlizzi](#) at the Max Planck Institute for the Physics of Complex Systems in Germany and his colleagues tested how the consistency of cacio e pepe sauce changed in hundreds of different recipes and developed science-backed guidance for how to stop the sauce becoming lumpy.

Di Terlizzi, who is Italian but is now based in Germany, came up with the idea while cooking with his Italian colleagues. “Pride played a little bit of a role in this because we cook a lot outside of Italy, because we miss our food,” he says. “I was cooking a lot, and 50 per cent of the time that I

was preparing cacio e pepe, I [messed] it up, and this was so terrible for my pride – I couldn't understand why."

To test different ingredient combinations, Di Terlizzi and his colleagues first mixed different proportions of cheese, starch and water together using a blender, before heating it in a pan with a sous vide cooker, a kind of heated water bath. Once a target temperature had been reached, they extracted some of the sample in a Petri dish and photographed it with a phone camera.

From these pictures, they could assemble what physicists call a phase diagram for cacio e pepe, which shows the different states the sauce can take under varying conditions, such as starch concentration or temperature. They found that one of the most important conditions for a smooth sauce is a starch level of 2 to 3 per cent. Pasta water is typically only around 1 per cent, so Di Terlizzi and his team recommend adding extra cornstarch.

When they kept the starch level fixed, they also found a relationship between the amount of cheese, which contains protein, and the lowest temperature at which the sauce starts to become clumpy. This relationship looked like a U-shaped curve: if the protein level was very low or very high, then this minimum temperature was higher, meaning the sauce would be stable at a wider range of temperatures.

The findings won't come as a shock to food scientists, says [Peter Fryer](#) at the University of Birmingham, UK. "Rule one in these things is that experiment is always ahead of theory, or people would not have been making pasta sauces for the last 1000 years."

The perfect cacio e pepe recipe

For two servings

- 240 g pasta
- 160 g pecorino cheese
- 4 g cornstarch in 40 ml water
- Black peppercorns, according to taste

Toast the peppercorns in a pan until fragrant, then grind them. Dissolve the cornstarch in water and heat until it forms a gel. Let this cool before combining it with the cheese and black pepper in a blender. Cook the pasta according to the packet instructions, then drain, reserving some of the water. Let it cool for a minute or so, then mix the pasta with the sauce. Add a little pasta water if needed to achieve the desired consistency.

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